



High-Yielding Cane Booklet

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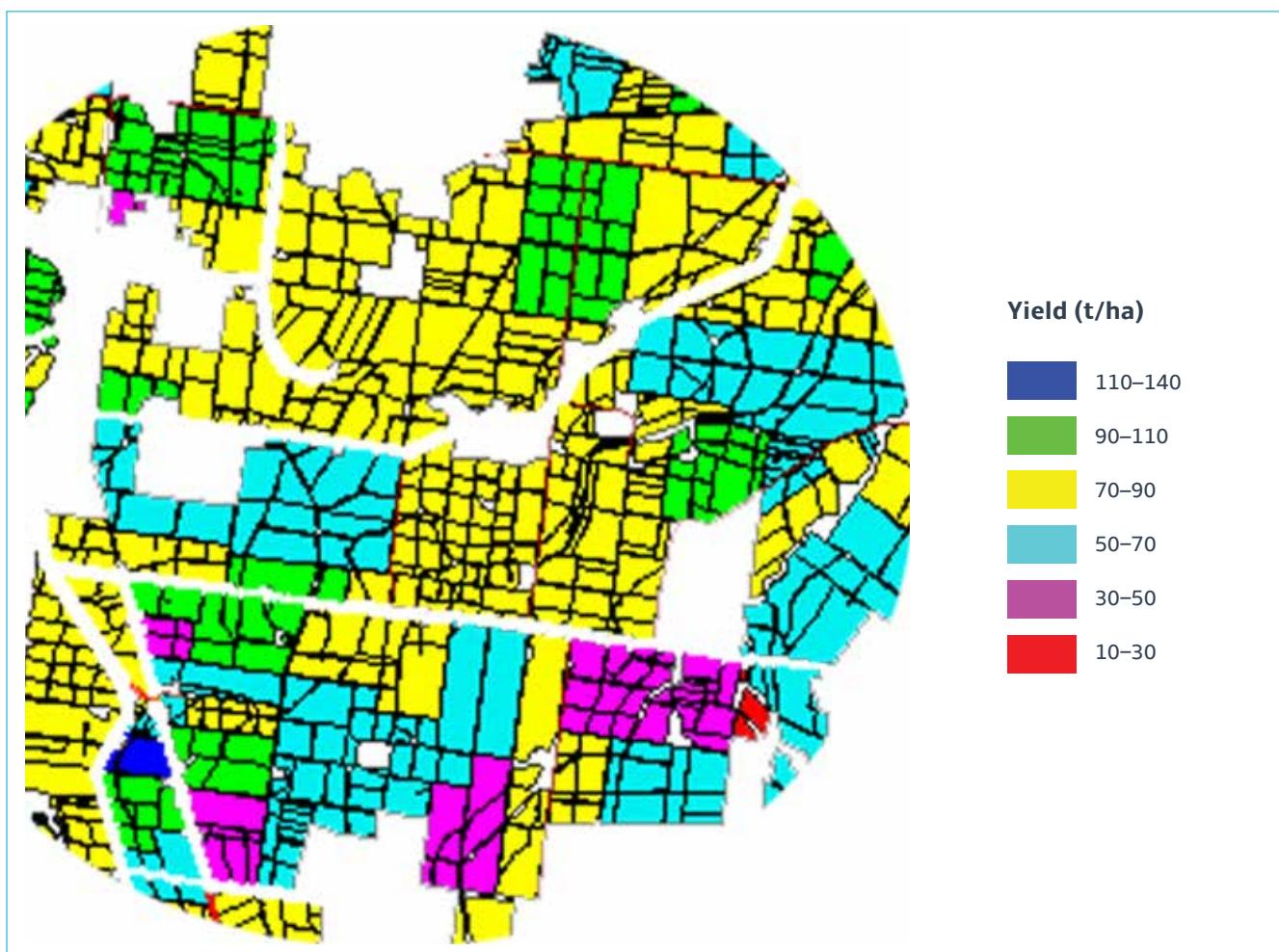
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Chapter 1

Introduction

The objective of the Australian sugar industry is to maximise yield while maintaining whole farm profitability. Yet, as shown in the figure below, the yield variability within similar productivity zones can be significant, leading to this question – why do some growers consistently produce higher yields than others who get similar rainfall and who farm on similar soils?

This booklet examines this variability and aims to show that yield is improved or reduced by the management decisions made throughout the crop production cycle. It also discusses how, with some attention to detail, average yields can be substantially increased.



Chapter 2

Fallow management

Key points for fallow management

- The fallow period occurs during the wet season so it is important that the fallow land is protected from erosion as much as possible. This is best achieved through having a soil cover in the form of a crop or trash blanket.
- Eliminate sugarcane regrowth from the fallow to break the soil-disease cycle.
- Plant legume cover crops to provide nitrogen for the following plant crop, maintain ground cover, reduce erosion, suppress weeds and diseases, and reduce seed soil banks.
- If you can manage pests, weeds and diseases to the required levels, grow the legume for harvesting, rather than green manure, to provide additional cash flow.
- Do soil testing early to determine nutrient and ameliorant requirements for the cane crop.
- Maintain effective weed control during the fallow, especially where hard-to-control weeds such as nutgrass were present in the last ratoon.
- Combine and broadcast ameliorants such as lime, gypsum or mill mud early in the fallow to allow time for them to be incorporated into the soil.
- Incorporate the cover crops close to cane planting to maximise nutrient availability for the plant cane.
- Plant a nematode-resistant legume as a rotation crop during the fallow period to reduce root lesion and root knot nematode populations where these are a problem.

A well-managed fallow will improve both the soil biology and soil structure, and should result in increased yields of 16 to 40 per cent in the following plant and ratoon crop.

A fallow can also be used to:

- manage weeds
- break disease cycles
- complete drainage works
- provide additional cash flow
- improve efficiency of operations.

Other considerations

- **Undertake earthworks in and around the block:** The fallow period is the only opportunity you have for land levelling operations in the block. In many cases, grassed headlands and waterways will have captured silt that has washed out of the block. These headlands and drains need to be lowered and cleaned out, and the fallow period is the perfect opportunity.
- **Manage soakage areas:** In some blocks, the installation of slotted underground drainage pipes could improve yield by removing excess groundwater.
- **Amalgamate and realign blocks:** Harvesting and farming efficiency is improved by increasing row length and the quality of on-farm roads and tracks.
- **Upgrade irrigation systems:** Many irrigation system upgrades require more underground pipe works or earthworks, which is only possible during the fallow.
- **Manage erosion risk:** The movement of sediment is one of the major contributors to reduced water quality. Block design needs to incorporate erosion management structures such as grassed waterways and contour banks.

Types of fallows

There are four main options available, and your choice will be dictated by the situation in each block:

- A bare, cultivated fallow
- A bare, sprayed fallow
- A weedy fallow
- A managed legume fallow.

References

Hurney A, Schroeder B, Calcino D, Allsopp P. (2008). *SmartCane fallow and land management*. BSES Ltd Technical Publication TE08009, 25 pp.

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Table 1

Fallow options.

Fallow type	Positives	Negatives	Recommended situations
Bare, cultivated fallow	Opportunity to conduct major earthworks No delay in planting at the end of the wet season	High potential for soil erosion Frequent tillage damages soil structure and disrupts soil organisms Tillage reduces accumulation of mineralised nitrogen	Only recommended when extensive earth works need to be done
Bare, sprayed fallow	Opportunity to control difficult weeds like nutgrass with inexpensive chemistry Beds can be formed prior to the wet season and kept clean ready for an early plant	Potential for soil erosion, but because the soil is undisturbed it is not as risky as a cultivated fallow	Where specific weeds are of concern
Weedy fallow	Easy to manage	Doesn't provide an effective break from pests and diseases, especially if there is volunteer cane Doesn't control weed problems	Weedy fallows are not recommended
Managed legume fallow	Different crop type provides a good break from cane pests and diseases (except root knot nematode) Adds nitrogen to the soil through the fixation of atmospheric nitrogen If taken to grain, provides an additional source of income	Requires commitment and management to do it well Crop residues can be difficult to manage at cane-planting time Growing a grain soybean crop delays cane planting until later in autumn at the earliest	In all other situations, a well-managed legume crop will provide the greatest benefits

Chapter 3

Selecting the right variety

Growing the right variety in the right place can have a large impact on your farm's productivity and profitability, so taking the time to choose the most suitable variety for a new plant block is critical.

Key considerations when choosing varieties to plant:

- Choose varieties with high yield and CCS potential in your district.
- Maximise the tonnes of sugar per hectare by selecting varieties by seasonal sugar profiles. Always plant a mix of early-, mid- and late-season varieties to maximise the CCS of harvested cane throughout the harvesting season.
- Choose varieties that are tolerant for a range of weather and environmental conditions including their ability to cope with premature arrowing and standover, and the speed of ratooning and emergence.
- Grow a range of varieties on your farm; plant no more than 40 per cent of any one variety to manage disease risk. See **Case Study 1**.
- Know your disease risk. Consider leaf and whole-plant diseases, as well as soil-borne diseases.
- Minimise the risk of spreading diseases by choosing a clean plant source for your seed/propagation material – either Cold-Soak Hot-Water Treatment from a clean source or tissue-culture plantlets.
- Choose varieties that best match the agronomic conditions on your farm, in particular, soil type and the need for irrigation.

Growing the most productive, locally adapted varieties

The yield potential of a new variety is an important consideration for growers. As a variety is grown more over a larger area of a district over time, more reliable yield-potential information becomes available.

SRA variety trials can compare the results of new varieties against standards (standards are a representation of the commercial QCanes used in the trial region). In **Table 1**, we can see that Q252[®] returned \$272 per hectare more than the average of the standards over plant, first and second ratoon from 2011 to 2013.

Table 1

SRA Final Assessment Trial Results from the Central region show \$/ha return of Q252[®] against the average of standards (Q238[®], Q232[®], KQ228[®], Q226[®], Q208[®], Q200[®] and Q183[®]).

The \$/ha calculation based on: Sugar Price \$350; Harvest Costs \$10 per tonne; Levies \$0.55 per tonne.

	2011 plant crop \$/ha	2012 1 st ratoon \$/ha	2013 2 nd ratoon \$/ha	Average \$/ha return over three harvests
Variety				
Q252 [®]	\$2369	\$2890	\$2859	\$2706
Average of standards	\$2151	\$2600	\$2551	\$2434

The best time to harvest a particular variety

Varieties have distinct sugar-accumulation curves so it is important to grow a range of early-, mid- and late-season varieties. Harvesting a variety that has high early-sugar late in the season, or a later-maturing variety early, can cost as much as 3.5 CCS units.

In **Figure 1**, the left box indicates Q231[®] being the best variety to harvest for CCS from week 24 to 40. The right box shows Q183[®] as the better choice to harvest for CCS from weeks 41 to 52.

Agronomic considerations and other factors

Information is captured at regional variety meetings to provide consolidated recommendations on variety response in a given agronomic condition or to environmental or weather impacts (see **Figure 2**).

Figure 1

Sample CCS curves relative to the mill average for example of early variety (Q231[®]) and late variety (Q183[®]) (from QCANESelect™).

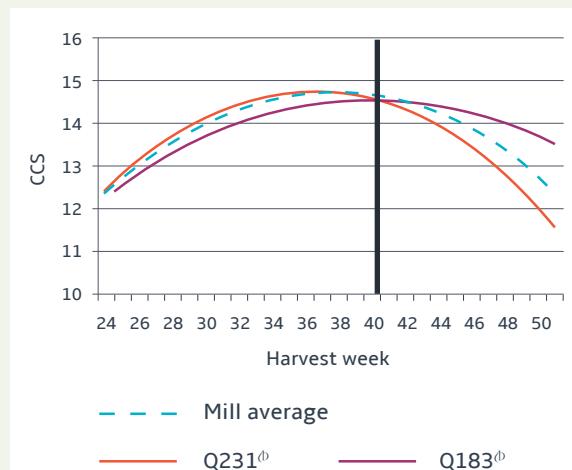


Figure 2

Example of regional Variety Guide suggestions for variety selection based on weather, environmental and agronomic conditions.

Northern Coastal

Variety	Canegrub tolerance	Tolerance to waterlogging	Flowering	Ratooning under wet conditions	Speed of germination	Reliability of germination
Q251 [®]	Unknown	Poor	Sparse	Poor	Average	Average
Q250 [®]	Unknown	Average	Sparse	Average	Average	Average
Q241 [®]	Unknown	Poor	Sparse	Poor	Average	Good
Q240 [®]	Unknown	Average	Moderate	Unknown	Average	Average
Q238 [®]	Unknown	Poor	Heavy	Poor	Rapid	Average
Q237 [®]	Unknown	Average	Moderate	Average	Average	Good
Q232 [®]	Poor	Average	Heavy	Unknown	Poor	Average
Q231 [®]	Unknown	Good	Heavy	Average	Average	Average
Q230 [®]	Unknown	Poor	Heavy	Average	Average	Average
Q219 [®]	Poor	Good	Sparse	Average	Average	Average
Q208 [®]	Poor	Average	Heavy	Average	Slow	Good
Q200 [®]	Poor	Poor	Moderate	Average	Rapid	Good
Q183 [®]	Unknown	Poor	Sparse	Average	Rapid	Good
KQ228 [®]	Poor	Average	Heavy	Average	Rapid	Good

The importance of planting a range of varieties

The Australian sugar industry has found out by hard experience that planting large areas of a single variety – however productive – leads to disease outbreaks and large yield and economic losses. **Case Study 1** shows what can happen if most, or all, of a farm is planted with one variety.

Case Study 1: Why plant a mix of varieties?

Until 2000, 85 per cent of cane growing in the Mackay region was variety Q124, with some farms growing 100 per cent of the variety.

Orange rust was a minor disease but the large area planted with Q124 produced heavy selection pressure for the development of more virulent strains.

In 2000, a virulent strain of orange rust emerged at Mackay, and cane yield fell by 40 per cent and CCS by 1 unit.

This cost the local industry an estimated \$200 million due to ploughing-out Q124, replanting other varieties, and shortened crop cycles. Planting a mix of high-yielding varieties reduces this risk.

Managing disease risk with variety selection

Choose varieties that are resistant to known diseases that currently exist on your farm, have a high chance of spreading from nearby farms, and which may reduce yield. Diseases that can be managed by variety selection are listed below in **Table 2**.

Table 2

Sugarcane diseases that can be managed by choosing the correct variety.

Leaf diseases	Whole-plant diseases	Soil-borne diseases
Brown rust	Chlorotic streak	Pachymetra root rot
Orange rust	Fiji leaf gall	
Yellow spot	Leaf scald	
	Mosaic	
	Sugarcane smut	

Managing disease risk with good planting material

Using approved seed cane is the best way to minimise major diseases such as chlorotic streak, leaf scald and ratoon stunting disease.

Buy approved seed every one to two years and plant only the first and second ratoon progeny from this approved seed.

This means that you should be planning for the planting of a new plant block at least a year in advance – and possibly longer – to give you the time to grow high-quality seed cane.

Tissue culture is an excellent source of clean seed for all varieties and can help reduce the spread of serious diseases such as ratoon stunting disease, smut and Fiji leaf gall.

Using tissue-culture plantlets allows earlier commercial-scale production of more-productive new varieties and will add value to your farming system.

Tissue-culture plantings are more uniform and produce more sticks than conventional plantings so larger quantities of planting material are made available.

Calculating the amount to order can be difficult so we have made it easier with our new online tissue-cultured plantlets calculator: www.sugarresearch.com.au/growing/cane/varieties – it demonstrates the speed at which large quantities of planting material can be produced from a set number of plantlets or for a set cost to the grower.

The calculator is self-explanatory with two case scenarios (**Figure 3**) given:

- Lower up-front cost; order fewer plantlets; whole-stick planting Year 2
- Labour saving; order more plantlets; billet planting Year 2.

Case Study 2: How much will tissue culture cost to suit my needs and how much planting material will I end up with?

Estimates of tissue-culture plantlet cost and quantity will depend on the size of the farm and needs of the individual grower.

For example (**Figure 3**), a grower on a large farm wants to trial a new variety, Q252[®]. The grower wants to plant about 16 to 17 hectares quickly by the third year, but minimise labour costs by not using a stick planter.

In this scenario the grower would use the billet-planting estimate.

By entering all the fixed variables (cost per plantlet, plant spacing, nursery plot estimates, billet planter rate and row width) the grower can then adjust the number of tissue-culture plantlets ordered (to 900) to provide the estimate of 16.91 hectares of Q252[®] planted in Year 3 at a tissue-culture cost of \$1350.

Tools to help with variety selection decisions

SRA provides printed annual Regional Variety Guides – for the Herbert-Northern, Burdekin-Central and Southern-NSW regions – and QCANESelect™ – an online tool to help make more-informed variety selection decisions, including the above key considerations. QCANESelect™ can be accessed on the SRA website: www.sugarresearch.com.au

The annual Regional Variety Guides can be found on the SRA website or ordered from SRA.

Figure 3

Two examples using the Tissue-Culture Calculator to estimate the cost and hectares planted from tissue-culture plantlets.

Calculator

Input YOUR information in the shaded cells below.

Whole stick option

Cheaper up front cost - order less plantlets - whole stick planting year 2.

Year 1 - Tissue culture

Input the price charged for each plantlet	1.50
Input the number of plantlets ordered	90
Total cost of order	\$ 135.00
Input the plant spacing between plantlets in metres	0.8
Length of row required for planting in metres	72

Year 2 - Whole stick planting

Input an estimate of the number of stalks per stool	12
Estimated metres of row planted using whole stick planter	2160
Input row width in metres	1.8
Estimated hectares planted using whole stick planter	0.39

Year 3 - Billet planting

Input estimate of cane yield on nursery plot in tonnes/ha	80
Estimated tonnes available for planting	31.20
Input the planting rate of your billet planter in tonnes of billets/ha	7

Billet-Planting option

Labour saving - order more plantlets - billet planting Year 2..

Year 1 - Tissue culture

Input the price charged for each plantlet	1.50
Input the number of plantlets ordered	900
Total cost of order	\$ 1350.00
Input the plant spacing between plantlets in metres	0.8

Year 2 - Billet planting

Input your estimate of the cane yield from nursery plot in tonnes/ha	80
Estimated tonnes available for planting	10.37
Input the planting rate of your billet planter in tonnes of billets/ha	7
Estimated hectares planted using billet planter	1.48

Year 3 - Billet planting

Input estimate of cane yield on nursery plot in tonnes/ha	80
Estimated tonnes available for planting	118.40
Input the planting rate of your billet planter in tonnes of billets/ha	7

Chapter 4

Crop establishment

Planting at the right time, having good-quality seed cane, and using a well set-up planter all maximise germination and lead to good crop establishment.

Crop establishment

Planting is one of the most expensive farming operations when growing cane and has a large impact on the long-term productivity of a block. Neglecting timing, plant source and good planting methods can lead to poor establishment and gappy stands; this in turn will reduce crop yields, reduce the number of ratoons from the block, and increase costs via the extra weed control in gappy stands.

Planting material



Above: Good-quality billets (top) compared to short, damaged billets (bottom).

Good-quality seed cane is critical to successful crop establishment. The best seed cane comes from an erect crop with short internodes (150–200 mm) with:

- undamaged eyes
- no internal piping (hollow centres)
- limited external damage.

Plan to buy approved seed every year to ensure a continual supply of disease-free seed cane to plant your commercial blocks. Grow your planting material as a dedicated seed source in a well-drained nursery block using reduced fertiliser rates to produce the desired short internodes and erect cane. Keep the nursery block free of weeds and volunteer cane and do not use lodged or damaged cane as it will not produce good-quality planting material.

Planting methods

Option 1: Whole-stick planters

Whole-stick planters have good metering systems to cut consistently-sized billets with minimal damage; however, the downsides are that they require straight cane for planting and have high labour costs.

The upside is that the low levels of sett damage by these planters means that planting rates of only 4–5 t/ha can achieve an even plant spacing, good emergence and the target plant populations of 3–4 plants/metre.

Option 2: Billet planters

Billet planters are now more popular because planting rates can be faster and it is a lower-cost option due to less labour requirements. The downside is that lower-quality cane is sometimes used as seed cane. However, there are options for improving the performance of billet planters if care is taken with seed cane billet harvesting (see **Box 1** for details) and planter set-up (see **Box 2** for details), especially if the seed cane is erect rather than lodged. The target billet length is 250–350 mm with two to three nodes and sound eyes, and without crushed/split ends or rind damage.

Box 1: Harvester set-up for cutting quality seed cane billets

Research shows that harvesters can be effectively modified to produce consistently sized billets with substantially less damage so this is a priority when planning planting operations.

Recommended harvester modifications for producing seed cane billets:

- chopper and basecutter blades should be sharp
- use rubber not toothed rollers
- match the roller and chopper speeds in the feed train
- maximum ground speed of 7-8 km/h
- billet length should be 250-350 mm.

Growers often increase the planting rate from 4-5 t/ha for whole-stick planters to 7.5-10 t/ha for billet planters to get a better plant stand, but research has shown that increasing the planting rate without modifying the planter metering system does not improve either evenness of the plant stand or cane yield. A key factor is that using low-quality seed cane in combination with high planting rates produces poor sett-to-soil contact; this hinders plant establishment and emergence.

Box 2: Planter set-up for an even plant stand and good plant establishment

A well set-up planter does five things:

- Evenly meters billets into the planting furrow to produce three or four plants/metre
- Places the billets into moist soil
- Gives good coverage of fungicide, and if necessary insecticide, on all billets
- Covers the setts with the right depth of soil, typically 40-100 mm, and
- Uses a press wheel to ensure good soil-to-sett contact.

Where high-quality billets are used, and the metering system has been modified to provide a more even flow of billets, good results can be achieved at planting rates similar to that of whole-stick planting (**Table 1**). This provides substantial savings in the amount of cane used for planting, allowing more cane to be sent to the mill to generate cash flow. It has been calculated that reducing the amount of cane used for planting could save the whole industry \$10 million per year.

Table 1

Cane and sugar yields from cane planted at three different rates (Homebush Innovative Farmers, 2009).

Planting rate (t/ha)	Cane yield (t/ha)	CCS	Sugar yield (t/ha)
3.7	123	14.7	18.1
5.5	127	14.8	18.8*
7.0	125	14.5	18.2

* Significantly more sugar than the lower and higher planting rates.

Timing of planting

The optimum planting time varies with the district depending on soil temperature and moisture, so follow your local district's recommendations on planting time (**Table 2**).

In the north, soil temperatures are usually high enough to plant at any time between autumn and spring, but it can be too wet to plant in autumn in the wet tropics. In southern and central areas, planting soil temperatures are too low in winter, so planting is best done in either autumn or spring. Regardless of the district, planting should be completed by October so that cane is established before the wet season.

The best soil temperature for germination and establishment is between 28 and 32°C. Planting should not occur when soil temperature is below 18°C because the rate of emergence is slowed dramatically. This, in turn, leaves the sett vulnerable to disease pathogens and can result in poor or patchy stands of cane.

Planting should occur into moist soil or be followed by irrigation.

Table 2

Preferred planting times for each district.

District	Preferred planting time
Tropical north coast and Herbert	March to September
Atherton Tableland	March to September
Burdekin	March to September
Central	April to May and August to September
Southern	March to April and August to September

Fungicides and insecticides

Pathogens can cause significant losses and under adverse conditions a total crop failure is possible if a fungicide is not used at planting. Fungicides should always be applied at planting to control pineapple sett rot. All of the fungicides registered in Australia for sugarcane planting material will provide protection until the crop emerges under normal conditions.

Billet planters have either a dip or a spray to apply fungicide to the billets. Check dips frequently for dirt and trash as these reduce the effectiveness of the fungicide. If spraying setts, check for proper coverage of the ends of the billets.

If wireworms are a problem, apply an insecticide at planting; bifenthrin, fipronil and chlorpyrifos are all registered for wireworm control. If planting in spring, insecticides for canegrub control can be applied at planting.

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For more details on planting, refer to *Guide for sugarcane planting*, SRA Booklet B14003. Internet resource available on the SRA website: www.sugarresearch.com.au

Chapter 5

Nutrient management

Nutrient management is one of the major production costs when growing sugarcane and makes up approximately 30 per cent of farm input costs. The Six Easy Steps nutrient management program provides the framework for effective nutrition management on your farm.

The importance of soil testing

Sugarcane requires a range of nutrients. Nitrogen, phosphorus, potassium, calcium, magnesium and sulfur are taken up and removed by the crop in tens to hundreds of kilograms per hectare while micronutrients such as zinc and copper are required in gram to kilogram amounts (Table 1).

A structured program of soil testing is the best way to determine nutrient and ameliorant (gypsum or lime) requirements. Soil testing should be conducted at the start of the fallow period to allow time for ameliorants to be applied and incorporated prior to planting, and for a nutrient management plan to be developed and implemented.

The benefits of a nutrient management plan

The key to formulating a nutrient management plan is to have balanced nutrition where all the required nutrients are supplied; the key issue here is that crop yield is determined by the nutrient that is most limiting.

In India, researchers recorded yield improvements of approximately 40 t/ha when all the required nutrients (N, P, K, S and Mg), as determined by a soil test, were supplied compared to the standard grower practice of applying nitrogen alone. This is an extreme result which occurred because the underlying fertility had been seriously degraded. Supplying just one or two nutrients when others are also required can cause serious declines in soil fertility and crop yields.

Table 1

Average nutrient removal rates by district (after Calcino, 1994), as kg/ha per tonne of cane harvested.

Nutrient	Mossman-Cairns	Babinda-Tully	Herbert	Burdekin	Mackay	Bundaberg	Maryborough-Rocky Point	Average
Nitrogen	1.43	1.31	1.73	1.29	1.46	1.63	1.58	1.49
Phosphorus	0.18	0.18	0.20	0.31	0.21	0.25	0.24	0.23
Potassium	2.17	2.24	1.88	2.32	2.42	2.83	2.75	2.37
Calcium	0.39	0.29	0.41	0.46	0.49	0.55	0.36	0.42
Magnesium	0.26	0.19	0.39	0.48	0.42	0.57	0.42	0.39
Sulfur	0.35	0.27	0.34	0.39	0.30	0.52	0.40	0.37
Copper	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Zinc	0.007	0.005	0.006	0.005	0.005	0.004	0.005	0.005
Iron	0.064	0.079	0.101	0.047	0.083	0.094	0.077	0.078
Manganese	0.068	0.042	0.066	0.016	0.043	0.029	0.034	0.043

Nutrients can be supplied from a number of sources including inorganic fertilisers, mill byproducts (e.g. mill mud, mill ash or mud-ash mixtures, biodunder), organic matter (e.g. legume crops, trash blankets, composts); and other ameliorants (e.g. gypsum, lime, calcium-magnesium blends). Include the nutrient content of any mill byproducts and ameliorants you apply as well as inorganic fertilisers to achieve an overall balance of applied nutrients.

Agronomic management practices will affect how efficiently nutrients are used. For example, uncontrolled weeds can rapidly use applied fertiliser and ineffective drainage can cause large nitrogen losses through denitrification.



Above: Inorganic fertiliser is the most common applied nutrient.

Fertiliser rate

Current nutrient management guidelines have been formulated to ensure that sufficient nutrients are applied for maximum productivity, without having excess nutrients available that could be lost from the system. Soil tests are used to determine nutrient application rates. For nitrogen, application rates are also based on crop-yield potential with discounts for nitrogen mineralised over the fallow or supplied from other sources such as legumes, mill mud or irrigation water.

Timing of fertiliser application

In plant cane, fertiliser applications are usually split. Some of the fertiliser is applied at planting with the remainder applied when the crop is at hill-up stage. In ratoon cane, where practical, apply fertiliser when the crop is approximately 50 cm high. By this stage, the new root system has established and the plant will be able to access and use the fertiliser.

If they are required, nitrogen, potassium and sulfur are generally applied every year. In contrast, phosphorus is largely immobile in the soil and the requirements for the plant crop and one or two ratoons can be applied at planting. Alternatively, phosphorus can be applied each year with the other macronutrients.

Micronutrients such as zinc and copper are usually only applied once per crop cycle in the plant crop, if a soil test shows these are needed. As these nutrients are required in very small quantities, the amount recommended will be sufficient for the entire crop cycle.

Ameliorants are usually applied during the fallow, allowing time for incorporation into the soil profile so that the nutrients are available for crop growth.

Placement of fertiliser

Nitrogen is very mobile in the soil and correct placement is critical to reduce losses. To minimise volatilisation, urea-based nitrogen fertilisers are best applied subsurface. Volatilisation (nitrogenous gaseous) losses from surface-applied urea fertiliser have been measured in trials at 40 per cent of the nitrogen applied. Also avoid very deep placement of nitrogen to avoid the risk of denitrification, i.e. nitrogen losses due to waterlogging. Keeping subsurface-applied fertiliser at or slightly above the level of the interspace usually provides the best results.

In plant cane, phosphorus and potassium fertilisers should be applied in a band to the side of the row. Care should be taken with potassium to avoid 'potash burn' which can occur when potassium is placed too close to the sett.

If sulfur is required, it is usually a component of other fertiliser products, e.g. ammonium sulfate, and is not applied separately. Gypsum is another good source of sulfur.

Lime (and related products, e.g. calcium-magnesium blends) and gypsum are usually broadcast and incorporated during the fallow period.

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Chapter 6

Weeds

Weeds restrict the sugarcane crop by competing for nutrients, sunlight and moisture and, in doing so, reduce cane yield. Viny weeds have the extra effect of entangling themselves in the crop, making harvesting difficult and reducing quality.

Research has shown that good weed control through the fallow period and the first 12 weeks of crop growth is critical to avoiding yield losses from weeds.

Where weeds were left uncontrolled for 12 weeks, yield losses were 18-50 per cent, depending on the weed species and crop, with losses being greater for dryland than irrigated crops. Nutgrass caused losses of approximately 30 per cent in trials, and mixed weed infestations up to 50 per cent loss (Figure 1 a & b).

The benefits of a long-term weed control approach

To achieve good weed control in cane, a long-term approach – rather than crisis management – is needed. This avoids major yield losses, minimises the ongoing weed-seed bank, and avoids off-farm environmental harm from herbicide use. Key components of a long-term weed management strategy for sugarcane are listed in **Box 1**.

Controlling weeds when they are small is easier, cheaper and more effective because lower herbicide rates can be used, and there is a greater range of products from which to choose. For example, sicklepod seedlings less than 50 cm tall can be treated with Tordon™ 75-D at 700 mL/ha, compared to 1.5 L/ha for seedlings more than 100 cm tall. This is a saving of around \$8.50 per hectare. Similarly, Agtryne at 2 L/ha is effective on broadleaf weeds up to the 4-leaf stage. Larger seedlings require a rate of 4 L/ha, costing approximately \$36 per hectare more.

Once cane reaches the out-of-hand stage, there is usually enough shading from the crop to restrict the growth of most weeds; weed control after the out-of-hand stage has been shown to have no effect on crop yield. The exception is vines, which may require control later in the growing season.

Green cane trash blanketing (GCTB) provides useful suppression of many weeds, especially grasses. However, if there are high soil seed banks and low trash levels, then a pre-emergent application soon after harvest is better than applying a pre-emergent later in the season. In addition, nutgrass is favoured by GCTB conditions, probably because of reduced competition from other weeds. Additionally, perennial weeds such as Guinea grass re-establish from stools or tap roots and so are also not controlled by trash blanketing.

Box 1: A planned approach to weed control in sugarcane

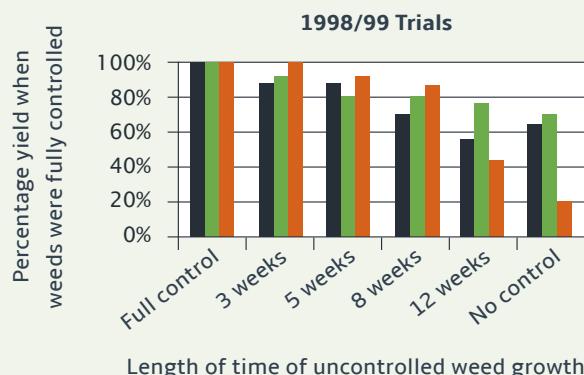
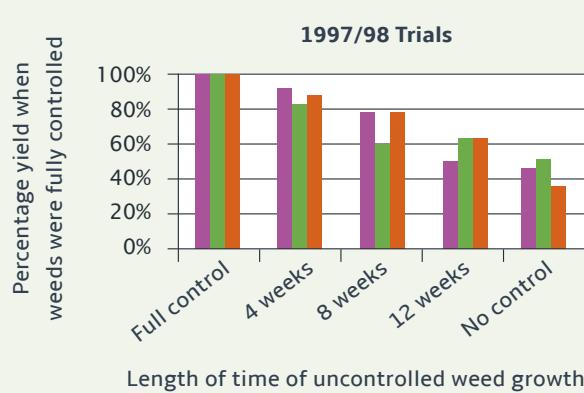
- 1) Eliminate weeds in the fallow, especially difficult weeds such as nutgrass.
- 2) Control all weeds before they set seed because this reduces the soil seed bank.
- 3) Avoid cultivation practices that invert the soil because this brings deeply buried weed seeds up to the germinating zone.
- 4) Make sure that weeds, especially perennials, do not get established in the young plant crop.
- 5) Keep the plant crop weed-free.
- 6) In ratoons, avoid crop losses from weeds by keeping the crop weed-free for the first six weeks and ensure that vines are controlled after this period.
- 7) By the second ratoon crop, weed control should require only one application of a knockdown herbicide.



Above: Crop growth is better 12 weeks after planting when weeds are controlled (top) compared to uncontrolled weeds (bottom). Where weeds were fully controlled, yield was 127 t/ha compared to 93 t/ha where control was delayed for 12 weeks.

Figure 1 a & b

Crop yield (as a percentage of the yield when weeds are fully controlled) for trials conducted during the 1997–98 and 1998–99 seasons in Innisfail, the Burdekin, Bundaberg and Mackay regions.



Economics

The economics of weed control varies widely, depending on the level of weed infestation and control methods used.

Weed control is always economic in fallow and plant cane. In plant cane, economic losses to nutgrass have been measured:

- In dryland crops: \$650/ha income loss after four weeks competition rising to \$1535/ha after 12 weeks competition.
- In irrigated crops: \$500/ha income loss after four weeks competition rising to \$868/ha after 12 weeks competition.

However, application of pre-emergent herbicides on trash-blanket ratoons does not always give an economic return.

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■ Innisfail ■ Bundaberg	■ Burdekin ■ Mackay
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Chapter 7

Diseases

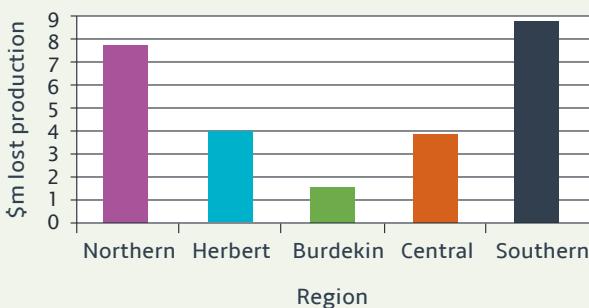
Disease outbreaks have had devastating industry-wide consequences in the Australian sugarcane industry, with the orange rust outbreak in 2000 costing the industry approximately \$200 million and sugarcane smut costing \$50 million in 2006. Because of the scale of losses from such outbreaks, it is critical to implement management strategies to reduce the outbreak risk at both the farm and regional levels.

Value of lost production for each region

Figure 1 illustrates the likely value of the lost production due to individual diseases for each region.

Figure 1

Estimated annual statewide losses from chlorotic streak, fiji leaf gall, brown rust, orange rust, yellow spot and ratoon stunting disease (average data 2008-2002).



The most important strategies for management of the major diseases in sugarcane are:

- the use of resistant varieties
- clean planting material
- fungicides
- crop rotation
- good farm hygiene and practices (especially machinery sterilisation)
- quarantine.

Some diseases require a combination of more than one of these strategies for maximum impact but resistant varieties are the mainstay of management for the most important diseases (**Table 1**).

Table 1

Summary of disease management strategies for sugarcane diseases.

Resistant varieties	Clean planting material	Hygiene	Quarantine	Fungicides	Crop rotation
Brown rust	Chlorotic streak	Leaf scald	Fiji leaf gall	Pineapple sett rot	Nematodes
Orange rust	Fiji leaf gall	Ratoon stunting disease	Mosaic		
Yellow spot	Leaf scald				
Chlorotic streak	Ratoon stunting disease				
Fiji leaf gall					
Leaf scald					
Mosaic					
Smut					
Pachymetra root rot					

Resistant varieties

Disease resistance is a key factor in determining whether varieties make it onto your mill area's list of approved varieties. The disease-resistance ratings are available through QCANESelect™ to assist with variety-selection decisions.

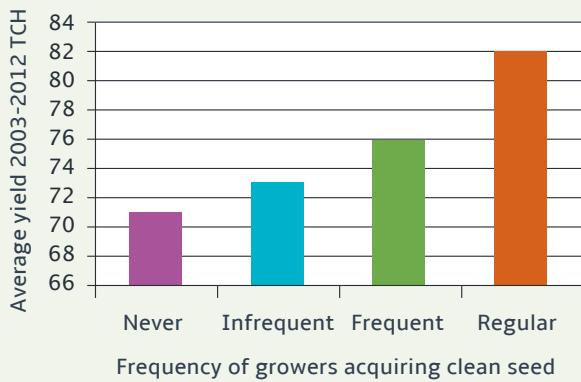
Clean planting material

There are two steps to implementing a clean planting-material strategy:

- Buy approved seed cane every year to plant seed-cane production blocks.
- Use the recommended hot and cold water treatment procedures to eliminate ratoon stunting disease, leaf scald, and chlorotic streak.
- Apply fungicide when planting.

Figure 2

Productivity benefits of planting clean seed in the Herbert. The yield difference between never and regular is 11.2 TCH. Data supplied by HPSL.



Fungicides and crop rotation

Pineapple sett rot is an exception; it is only controlled by fungicides at planting. It is essential to use registered products on seed cane at planting time. Nematodes are best managed using crop rotation with nematode-resistant legumes.

Farm hygiene

There are three critical elements to good farm hygiene:

- Clean and disinfect machinery, especially planting and harvesting machinery.
- Minimise the incidence of alternate hosts on your farm, especially Guinea grass, corn and elephant grass.

- Destroy diseased crops and volunteer cane in abandoned fields.

Together, these farm hygiene actions reduce the disease reservoirs on your farm and break the disease-transmission cycle that can occur from machinery.

Quarantine

Quarantine operates at a regional level rather than a farm level and is the regional equivalent of the on-farm clean plant material and hygiene measures already discussed.

Fiji leaf gall, mosaic and sugarcane striate mosaic are three of the most important targets of quarantine regulations in Queensland.

Regional quarantine regulations support your efforts to manage disease on-farm by preventing movement of diseases between regions. There are seven quarantine areas in Queensland and quarantine restrictions apply to both sugarcane plant material and equipment that has been in contact with cane or soil in which cane has grown.

Approval by a Plant Protection Act (PPA) Inspector is required prior to movement. In most areas, some productivity services staff have been appointed Inspectors by the Department of Agriculture, Fisheries and Forestry Queensland (DAFFQ) and can facilitate movement approvals.

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Chapter 8

Pests

Two groups of pests – canegrubs and rats – are the major pests of Australian sugar. Other insect pests, such as soldier flies, pigs, wallabies and cockatoos, may cause economic damage in some regions or years, but are generally much less serious.

Canegrubs

Control of canegrubs in high-risk fields will always be economical, unless sufficient damage has already occurred to warrant plough-out. Yield increases of up to 26 per cent compared to the untreated control have been demonstrated against greyback canegrub.

The cost of Conidor® Guard treatment is offset by harvesting only an extra 1.2-1.6 t/ha if applied at the same time as another farming operation. suSCon® maxi for Childers and southern one-year grubs requires harvest of an extra 3 t/ha for 3 years to pay for the chemical cost while for greyback canegrub an extra 5 t/ha is required for 2 years to cover the insecticide cost (see **Table 1**).

Nineteen species of canegrub are recognised as pests of sugarcane in Queensland but the importance of the species varies between districts. At least one canegrub species is present in each mill district, but up to nine species may occur in a region, with up to three species being found in an individual field.

Accurately identifying canegrubs

Knowing which species of canegrub are present in your district – and on your farm – is vital because the different species have different behaviours, different lengths of life cycle (one or two year) and vary in susceptibility to insecticides.

Life cycles are either annual or two-year, with crop damage typically occurring at different times for the different types of grub. One-year grubs typically damage well-grown crops from late summer through to autumn while two-year grubs mostly damage young ratoon cane in spring and early summer.

The greyback canegrub is the most damaging species, occurring from Plane Creek mill area northwards.

It causes annual losses of \$5-\$10 million but damage can be much higher in outbreaks years. Other major species are the French's and negatoria grubs (both two-year species), Childers canegrub and southern one-year grub. Some species occur in both one-year and two-year forms, and this complicates management decisions.

Managing canegrubs with insecticides

Seek local advice on your canegrub species as insecticide registrations vary between species and production regions. Insecticides provide the most effective control of canegrubs but it is not necessary – or desirable – to treat all fields, every year. The best approach is to identify high-risk fields and concentrate treatments on those fields (see **Box 1**). A risk-management strategy should be implemented for other fields; this involves checking for signs of damage both before and after harvest, and knowing if adjacent fields have been infested; based on this information then decide to treat, or not, depending on the degree of risk. The frequency and timing of treatment will vary with the insecticide and the canegrub species.

Box 1: Identify high-risk fields for canegrubs

Identify and treat high-risk fields if the soil type is conducive to the relevant species. High-risk fields are:

- Fields with a history of grub problem.
- Fields next to fields with active canegrub damage.
- Fields located on hillsides in areas where canegrubs are active because flying adults are attracted to taller cane and cane on hillsides appears 'taller' than other fields.
- Fields that are near known adult-feeding trees, e.g. sandpaper figs along river banks in the Burdekin region.

The economics of canegrub treatment

The following examples compare the cost of treatment against the amount of cane needed to be 'saved' from canegrubs to pay for that protection. Insecticides applied indiscriminately to blocks that are not at risk is a waste of money.

Table 1

Examples of estimated cost of treatment and tonnes of cane needed to offset cost.

Confidor® Guard	Cost/ha (1.8 m row spacing)	Tonnes cane to offset cost#
16 mL/100 m row	\$32	1.2 t/ha
22 mL/100 m row	\$44	1.6 t/ha
Tractor and labour @ 3.4 ha/h (3 row applicator)	\$16	0.6 t/ha
Application cost is only an extra cost if applied separately; application is commonly included in planting, fertilising or hillng-up operations		
suSCon® maxi	Cost/ha (1.8 m row spacing)	Tonnes cane to offset cost#
150 g/100 m row (Childers & southern one-year)	\$96/year for 3 years	3 t/ha for 3 years
225 g/100 m row (greyback)	\$144/year for 2 years	5 t/ha for 2 years
Application normally included as part of planting, fill-in or hill-up operations		
# based on grower cane price of \$28/tonne nett of harvest cost Capital cost of application equipment not included as this varies considerably with set-up and area treated		

Rats

In the 1999 and 2000 seasons, rats destroyed 825,000 tonnes of cane worth \$25 million.

Rodents are the second most serious pest of the Australian sugar industry after canegrubs. Two indigenous rat species affect cane; the ground rat (*Rattus sordidus*) and the climbing rat (*Melomys burtoni*).

As both rat species are native animals, they are protected species and their management in Queensland is subject to a Memorandum of Understanding (MOU) between the sugar industry and the Queensland Government.

Under the MOU, an industry-wide Damage Mitigation Permit is issued, rather than individual growers needing to apply for their own Damage Mitigation Permit. Under the MOU, growers have a responsibility to report baiting activities to their respective productivity services group.

Rats are controlled using an integrated pest management (IPM) approach, combining:

- In-crop weed control to reduce the availability of weed seeds as these are a vital protein source that stimulates breeding and reduces in-crop harbourage.
- Management of non-crop harbourage areas; rat numbers are reduced when there are no suitable harbourage areas close to the crop.
- Strategic baiting (permitted only between 1 October and 30 June); baiting should aim to reduce rat populations before peak breeding occurs.

This integrated approach is essential as baiting alone is usually insufficient to manage rats. Baiting needs to occur early in the rat's reproductive cycle; once peak breeding occurs, reproduction rates far exceed death rates from baiting. Timing of baiting for each species is different so it is important to know which species is the predominant pest on your farm.

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Chapter 9

Irrigation and drainage management

Sugarcane originated in the wet tropics and so to achieve maximum yield, it requires an abundant supply of water, either as rainfall, irrigation or a combination of both. Under good growing conditions, approximately 10 t of cane is produced for each megalitre of soil water used. However, experiments have shown that efficient irrigation systems can produce up to 15 t/ML of water. Conversely, moisture stress reduces cane yield, with industry losses from water stress estimated to be in the range \$65-305 million. Consequently, managing your available water resources is one of the keys to profitable sugarcane production.

Some practical advice

- Water standing cane during the harvest period to maintain growth and condition.
- Dry down cane six to eight weeks prior to harvest to increase sugar content.
- Water young ratoons to maximise yield.
- In very dry conditions a better ratoon may be established by watering the standing cane rather than the young ratoon.

Does irrigation pay?

The rising cost of electricity for pumping, and high water costs, have some growers wondering if irrigation is still

a profitable operation. The answer to this question will depend on an individual's farm operational costs, and the following information may help to make this decision.

The cost of irrigation

Water costs

Water charges are highly variable throughout the industry. In some regions, growers have access to low-cost water from bores or unregulated streams, whereas in other regions growers who need to rely on irrigation schemes can pay from \$50 to \$120 per ML.

Pumping costs

Some growers are able to operate irrigation systems directly from the irrigation outlet with no pumping cost. A recent survey of electricity usage found that a typical low-pressure system such as a centre pivot had a pumping cost of \$55/ML, while a high-pressure system such as a water winch had a pumping cost of \$90 per ML.

Income growth from irrigation

The income produced as a result of irrigation can be measured by the cane yield response to applied water. Typically, cane yields are increased by six to 10 tonnes of cane for each ML of water applied. If cane is priced at \$40/t and the harvesting cost is \$10/t then an extra \$30 of income can be generated for each additional tonne of cane grown. A few scenarios are shown in **Table 1**.

Table 1

		Furrow direct from outlet – no pumping	Low-pressure centre pivot	High-pressure water winch
Income/ha	Extra cane grown per ML	6 t	10 t	8 t
	Extra income per ML	\$180	\$300	\$240
Less costs	Water cost	\$60	\$90	\$90
	Pumping cost	0	\$55	\$90
= Profit/ha from irrigating		\$120	\$155	\$60

When and how much to irrigate

In planning irrigation strategies, three key factors determine the amount and timing of irrigation:

- The rate of water use by the growing crop
- The soil profile's water-holding capacity
- Irrigation water quality.

Crop water use

Research has shown that supplying approximately 85 per cent of crop water requirements produces similar sugar yields as meeting 100 per cent of water requirements. This occurs because supplying 100 per cent of water requirements maximises cane yield but reduces CCS. Therefore, farm productivity can be maximised by aiming to supply approximately 85 per cent of crop water requirements; Holden and McGuire (2014) provide the details of how to achieve this for each soil type on your farm using evaporation minipans.

Soil water-holding capacity

The other key factor in calculating irrigation requirements is your soil profile's water-holding capacity. This has two components:

- Soil type
- Effective rooting depth.

Sandy soils do not hold as much water as clay soils, and so require more frequent irrigation than heavy clay soils. Effective rooting depth is between 0.9 and 1.2 m on irrigated deep soils and up to 1.8 m under rain-fed conditions, but is restricted to just the top soil on sodic duplex soils. Together, these two components set the total amount of water in the profile that is available for plant growth. This in turn establishes the maximum amount of water that can be applied per irrigation and the irrigation frequency; on heavy soils larger amounts of water can be applied less frequently, but on sandy soils smaller amounts of water need to be applied more frequently for maximum sugar production.



Above: Over half of the Australian crop receives some level of irrigation.

Water quality is a key issue and irrigation waters of different qualities need to be managed in different ways to maximise productivity and to avoid long-term soil structure and drainage problems such as salinity and sodicity. SRA's 2014 *Irrigation of Sugarcane Manual* provides the details of how the salinity and residual-alkali quality of your irrigation water interacts with specific soil types. If poorly managed, problems such as poor water penetration and water-stress symptoms in wet soil can occur but these can be avoided with correct management.

Irrigation timing. Managing the timing of irrigation and water stress is one of the keys to maximising productivity, especially if you have limited water for irrigation. Cane is relatively tolerant of water stress when the crop is in the early tillering phase; stress at this time will reduce leaf area, tillering and biomass production but will have little impact on final yield. However, water stress should be avoided when the crop is actively growing. Finally, some water stress during ripening is considered desirable to maximise sugar content.

Irrigation systems. There are four main choices for irrigation systems in sugarcane:

- furrow irrigation
- high-pressure overhead systems
- low-pressure overhead systems
- drip irrigation.

Many factors determine which of these is best for any specific situation: water availability and quality, soil type and slope, capital cost and labour availability are some of the most important factors to consider.

In fully irrigated areas, schedule irrigations to occur when stem elongation drops to 50 per cent of the maximum rate.

The details of the process of calibrating minipan evaporation to this 50 per cent point are described in the *Irrigation of Sugarcane Manual* (Holden and McGuire 2014); once calibrated, this system provides a quick method of achieving optimal irrigation schedules, and so maximises your sugar yields from fully irrigated sugarcane.

In areas using supplementary irrigation, the timing of irrigation becomes more difficult. With a summer-dominated rainfall pattern, early ratoon crops and plant cane will benefit more from irrigation prior to the wet season as there is only a short growing period after the wet finishes. For late-cut crops, irrigating after the wet season will limit the amount of water stress (Attard and Inman-Bamber, 2011).

Drainage

Sugarcane stops growing when it is waterlogged. Research shows a yield loss of 0.5 t/ha for every day that the watertable is within 50 cm of the surface; that is, waterlogging costs you money in lost crop growth.

Additionally, applied nitrogen fertiliser is lost by denitrification during periods of waterlogging, and phosphorus and other nutrients become less available. Poorly drained soils can also present problems with correctly timing the planting, cultivation and harvesting operations.

Good surface drainage can prevent ponding during wet periods; land planing can improve this. Adequate surface drainage can reduce the need for expensive sub-surface drainage options. However, where watertables are high, sub-surface drainage is required to keep the water table at least 50 cm below the soil surface; this can involve sub-surface plastic pipe, mole drains, or open drains.

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Chapter 10

Harvesting

Large – and largely avoidable – harvesting losses can occur because of poor cane pickup (1-10 per cent), chopper losses (2-8 per cent), or via the harvester's cleaning system (5-25 per cent).

Poor harvesting practices can also damage the stool, reducing the yield of the following ratoons and limiting the number of ratoons that can be grown. That is, poor harvesting management can negate all the work that has gone into growing a high-yielding crop and can have very large impacts on your farm's profitability.

The *Harvesting best practice manual* brings together current research, innovations, and thinking on optimal harvesting practices and provides new insights into optimising this critical stage of producing a profitable cane crop.

For the best cane and sugar yields, the crop needs to be mature. Crops that are 12 months old, or older, will have had sufficient time to accumulate biomass and sucrose. Crops harvested at less than 12 months are likely to suffer from lower yields or suppressed CCS levels. Planning the harvest rotation to take into account crop age and the variety's CCS curves allow you to maximise returns.

In Louisiana, planning the harvest schedule so that each field was harvested at the optimum time increased returns by approximately US \$76 per hectare (US \$31/ac). SRA variety guides and QCANESelect™ include the best time to harvest each variety, so use this information when planning your harvesting schedule.

Harvester losses

A number of factors can affect harvester performance and losses, including:

- cane yield
- whether the crop is erect or lodged
- if the cane is being harvested green or burnt
- the uniformity of row spacing and the row length
- field layout and harvesting conditions
- if the row spacing and machine are matched
- condition and maintenance of machinery
- operator proficiency.

Many of these are controllable via how you implement your farm management practices or through clear guidelines for harvesting contractors. All contribute to maximising the productivity of your farm.

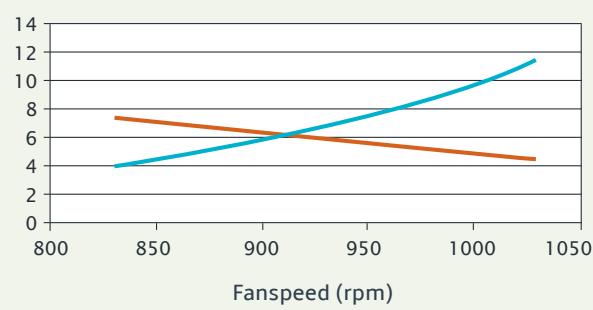
Harvester cleaning systems

In green-cane systems, the greatest harvesting losses occur in the harvester's cleaning system, with losses of 5-25 per cent being measured.

This is generally because operators increase the speed of the extractor fans in an attempt to reduce extraneous matter and to maintain bin weights. However, this results in large losses of cane billets for very small improvements in extraneous matter levels (**Figure 1**).

Figure 1

Effect of increasing fan speed on cane loss and extraneous matter levels (SRA, 2014).



In practice, the most effective way to reduce extraneous matter is to reduce the pour rate (Figure 2). However, reducing harvester pour rate will result in increased time to harvest a set amount of cane with a corresponding increase in harvesting cost; it is a matter of your judgement where the balance lies between harvesting speed and harvesting losses, and between the level of extraneous matter and bin weights.

Figure 2

Effect of pour rate and extractor speed on extraneous matter levels (SRA, 2014).

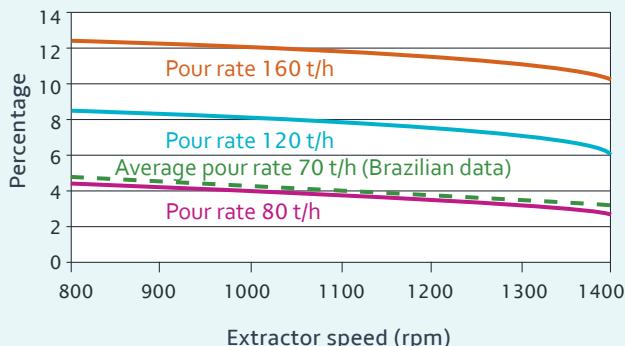


Figure 3 shows cane loss from a standard John Deere extractor chamber. Cane loss rises rapidly as extractor fanspeeds increase above 800 rpm. This is in contrast with older models; their losses start to increase rapidly above 1000 rpm (Figure 4).

Figure 3

John Deere cane loss versus fan speed.

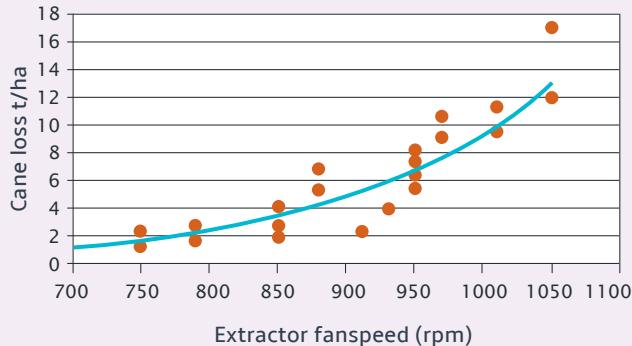
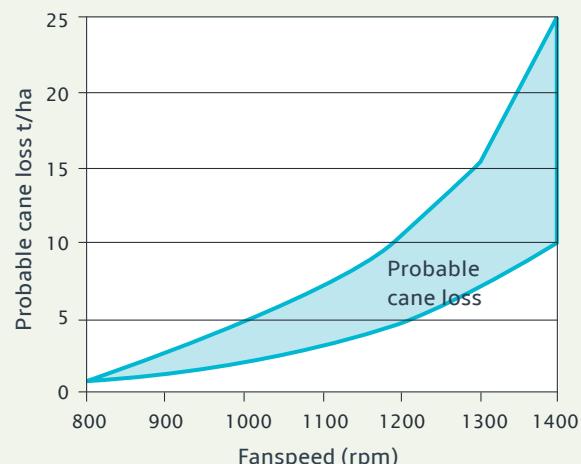


Figure 4

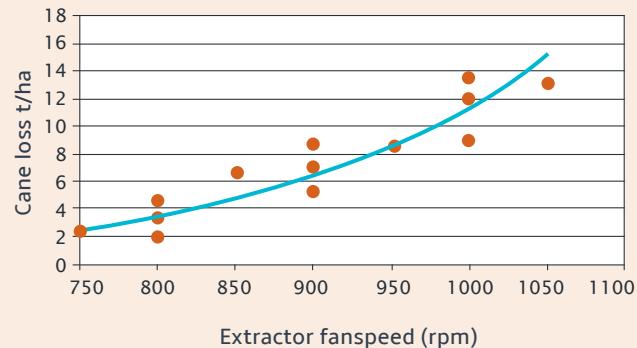
Cane loss versus fan speed – earlier model machines.



The 'anti-vortex' extractor design is standard to the current model Case IH harvester but retro fitted kits are available to suit earlier machines. As with the John Deere system, losses increase exponentially above 800 rpm (Figure 5).

Figure 5

Anti-vortex cane loss versus fan speed.



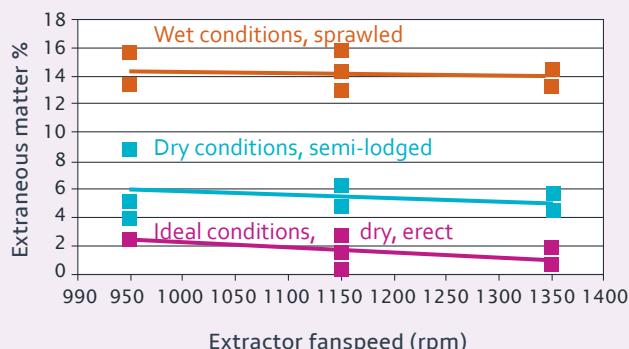
With losses of up to \$1500/ha being measured in SRA field trials over recent years, it's important operators are aware of the impact fan speed has on cane loss.

Lodged and wet cane

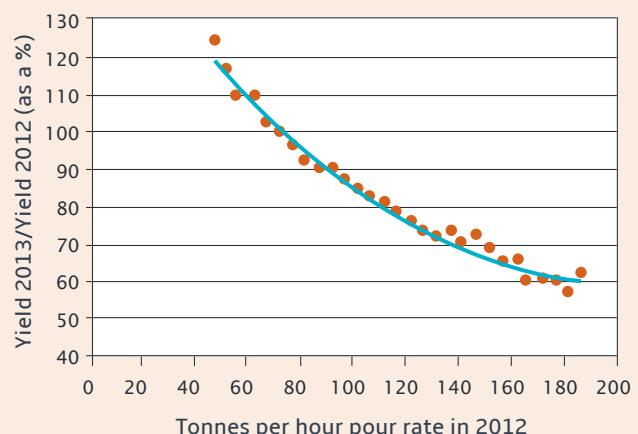
Cane that is lodged presents major problems for the harvester's gathering and pickup systems. Cutting a field only in the direction that the cane has lodged will cause the least damage to the cane stool; trials have shown that harvesting one way – in the direction the cane has lodged – reduced stool damage from 52 per cent to 18 per cent. Wet cane also presents problems for the cleaning system. The cane leaf and trash tend to clump together, making their extraction and separation more difficult. This causes increased extraneous matter levels (Figure 6).

Figure 6

Effect of crop conditions on extraneous matter levels (SRA, 2014).

**Figure 8**

The impact of pour rate in 2012 on productivity in 2013 in the Herbert region (SRA, 2014).



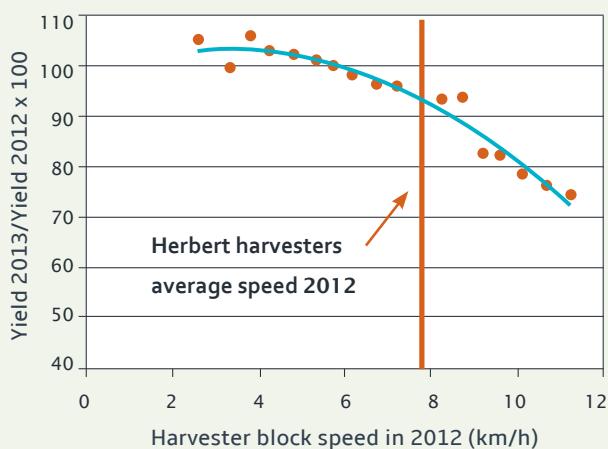
Effect of harvesting on ratooning

Harvesting can impair the subsequent ratooning ability of a crop. High forward speeds and high pour rates can cause a yield reduction in the following ratoon crop (**Figures 7 and 8**). This reduction is caused by damage to the stool by splitting and shattering and the physical removal of stools.

Trials conducted in the Burdekin, Mackay and Tully districts found that more than one-third of stools had suffered serious damage during the harvesting operation, either as deep splits, or shattering and splitting. This damage provided an entry point for diseases and resulted in a 40 per cent reduction in ratooning.

Figure 7

The impact of forward speed in 2012 on productivity in 2013 in the Herbert region (SRA, 2014).



Basecutter maintenance and operation is critical to minimising stool damage. For a given speed, an overly high basecutter rpm will result in stools being cut by the blades multiple times. This will reduce the ratooning of the stool and increase blade wear. Far worse than this is when basecutter rpm is too slow for the forward speed – it significantly reduces ratooning by tearing the stalk, and increases soil in cane supply. The disc tears off stalks before a blade reaches the stalk, causing severe damage to the stool.

To minimise the effect of disc-to-stool contact, ideally basecutters should have six blades per disc. Having the extra blade per rotation leads to less disc-to-stool contact and improves the quality of the cut. The operator should aim to skim the surface with the basecutters cutting the cane at ground level. Worn blades should be replaced as often as possible.

Trials found that worn basecutter blades cut less effectively. Operators then tended to lower the cutting height to compensate. This led to a 34 t/ha reduction in yield in the next crop as a result of cutting below ground and removing stools. A 34 t/ha reduction in yield at \$40/t means a \$1360 loss per hectare. Equally, cutting too high will lead to increased shattering and splitting of the stubble. Ensuring that the basecutter angle and the row profile match will also improve the cutting operation and minimise stool damage.

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